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**TRANSITION OF BEDROCK TO SAPROLITE IN THE ROCKS
UNDERLYING THE LOUDOUN COUNTY LANDFILL AND SITE L**

Chemical weathering of the rocks that underlie the Loudoun Landfill site and the proposed extension, Site L, has resulted in the development of a thick mantle of residual materials. The stratigraphy that develops during the weathering process has been well documented in the Piedmont region of Virginia (Pavich, et. al., 1989) and elsewhere. The investigation at the Loudoun Landfill has shown that unweathered bedrock is overlain by partially weathered bedrock zone (transition zone) which is in turn overlain by saprolite (Figure 1). Within the weathered bedrock zone the fractures have been enhanced by the onset of chemical weathering but often remain open to groundwater flow. In several cases, the weathered bedrock zone (transition zone) is more transmissive than the underlying bedrock or overlying saprolite.

The degree of chemical weathering is highly dependent on the type of bedrock and the amount of fracturing present. Within the area under discussion, the bedrock is a clast rich conglomerate of the Goose Creek member of the Catharpin Formation (Lee and Froelich, 1989). The general characteristics of this bedrock and the saprolite derived from it (as observed by EGGI geologists) are presented below. This is followed by descriptions of specific wells that highlight the great variability observed in the characteristics of the weathered bedrock zone and saprolite.

Bedrock: Red to red-brown, very poorly sorted conglomerate with sub-rounded, matrix supported clasts and carbonate cement. Clasts range from fine cobbles to boulders in excess of 0.5 meters diameter and include: quartzite (~40%); tan to pale gray, microcrystalline, massive to moderately bedded limestone (~20%); massive to very well foliated greenstone-greenschist (~30%); red to red-brown, micaceous, arkosic sandstone and siltstone (~10%). Quartzite clasts are mostly of three types: gray, micaceous, moderately to poorly foliated, impure quartzite (~40-60%); dark gray to black, hematite-bearing, coarse crystalline, white vein quartz

and/or quartzite (=25%); and gray-white-pale green, fine grained quartzite (=10-20%). The matrix comprises 30-50% of the rock and is poorly sorted, fine to coarse, quartz-rich sand and silt cemented with carbonate. Locally, carbonate-coated fractures occur.

Saprolite: Red to red-brown, silty to clayey saprolite with 0 to 20 % fine to coarse feldspar/quartz sand and variably altered clasts of quartzite and greenstone-greenschist and subordinate siltstone/sandstone and micaceous schist. Bedding structure is locally preserved. All carbonate in the matrix and the limestone clasts of the protolith are absent. Wholly altered protolith clasts occur as yellow, tan, brown, and orange clay-rich pods in the saprolite matrix. In general, the percentage of unaltered clasts increases with depth.

Weathering within the saprolite is highly variable due to: compositional changes in the parent conglomerate, type of clasts found within the conglomerate, and to variations in fracture density. Quartz clasts are resistant to chemical weathering and occur from the ground surface downwards. Greenschist/greenstone clasts are less resistant to weathering and were generally observed within 20 feet of the bedrock surface (i.e., L1D and L15-P2 and others). Carbonate rocks are highly susceptible to chemical weathering and are present only within the competent bedrock. The fine-grained matrix within the conglomerate is usually completely weathered from the ground-surface to within 6 inches to 5 feet of the bedrock surface (except as observed in MW-18). This variably thick zone of moderately weathered to unweathered matrix found above the competent bedrock surface make up, in part, the transition zone which can be more transmissive to groundwater flow.

Since weathering progresses outwards from the relict bedrock fractures, in addition to downward from the ground surface, small enclaves of competent rock can be preserved within highly weathered saprolite. This can cause confusion in defining the bedrock surface elevations. For example, in monitoring well L8 a competent bedrock boulder was intercepted from 47 to 63 feet. Saprolite extended below this boulder to the base of the well (140 feet deep). Conversely, in monitoring well MW-21A a zone of highly weathered saprolite was intercepted from 25 to 45 feet

within otherwise competent bedrock. This may indicate that the presence of a bedrock boulder or an overhang of bedrock surface (pendant).

Groundwater yields derived from the weathered zone (transition zone) are also highly variable. Eight of the wells drilled at the Landfill site derived significant water from the weathered bedrock zone. These include monitoring wells MW-30 (>150 gpm), L11 (120 gpm), L26 (100 gpm), L23 (20 gpm), L18 (40 gpm), L4 (>10 gpm), L2 (>10 gpm), and L7 (8-10 gpm). In MW-30 the water producing zone was an approximately 3 foot thick "bed" of medium to coarse clasts derived from the underlying conglomerate. The matrix appeared to have been selectively removed out at this interval.

In summary, the transition zone (as we have observed it in the field) is located at the top or near the competent bedrock surface.¹ This zone has ranged in thickness from 0.5 ft to approximately 3 to 7 feet with the exception of Well MW-18 which appeared to have a transition zone as thick as 15 feet. The transition zone is composed of unweathered to slightly weathered clasts of quartz, greenschist/greenstone, sandstone, siltstone, biotite schist, and moderately weathered clasts of carbonate rocks. The fine-grained arkosic matrix of the conglomerate (host rock) is typically unweathered to moderately weathered with the least amount of weathering occurring at the base of the transition zone (i.e., top of bedrock). The water-bearing capability of the transition zone varies. Observed yields from borholes intercepting this zone ranged from <1 gpm (L7D) to >150 gpm (MW-30).

¹Competent bedrock is defined in the field on the basis of changes in drilling characteristics and the lack of weathering of the rocks. At the bedrock interface the drilling hammer noise increases, the bit begins to bounce, the rate of drilling slows down considerably, and the cuttings become fragmental with sharp well defined edges. Where water is absent the drilling dust/cuttings change from a dark brown to light gray. The start of unweathered bedrock is also defined as the point at which the carbonate cement in the matrix reacts to HCL acid. The presence of the carbonate minerals in the rocks indicate that the rock is essentially unweathered.

FAST TRACK MEMO TO: Rob Montgomery, Rich Ryan
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Emery & Garrett Groundwater, Inc.

GENERAL PROPERTIES OF WEATHERING PROFILES

Description of weathering profile for igneous and metasedimentary rocks in Fairfax County, Va.
(modified from Deere and Patton, 1971)

Zone	Descriptions ¹	RQD ² (% core percent)	Percent core recovery (% core)	Relative permeability	Relative strength	Common thickness (feet)
Soil	A Horizon..... Top soil, roots, organic material. Zone of leaching and eluviation. Generally porous and sandy.	Not applicable.	0	Medium to high ..	Very low ...	0.1-0.3
	B Horizon..... Characteristically clay enriched, also accumulations of Fe and Al. No relict structures present.	Not applicable.	0	Low.....	Commonly low, medium if very dry.	0.3-1.0
Massive subsoil	No relict rock structure. Less dense than soil B horizon. Less clay than soil B horizon. Depleted in cations and silica relative to Fe and Al. May contain clasts of saprolite.	Not applicable.	0	Medium.....	Low.....	0.5-1.0
Saprolite	Relict rock structures retained. Clay-bearing silt or clay-bearing sand grading to sand at depth. Commonly micaceous; feldspars and mafic minerals altered to clays. Less than 10 percent core stones. Joints strongly cemented with oxides at many places.	0 or not applicable.	Generally 0-10 percent.	Medium.....	Low to medium (relict structures very significant).	1-15
Weathered rock	Transition (from saprolite to partly weathered rock). Highly variable, saprolitic to rocklike. Fines commonly fine to coarse sand (grus). 10-85 percent core stones. Feldspars and mafic minerals altered in part.	Variable, generally 0-50 percent.	Variable, generally 10-90 percent.	High (water losses common during drilling).	Medium to low where weak structures and relict structures are present.	0.3-3
	Partly weathered rock. Rocklike, soft to hard rock. Joints stained to altered. Slight alteration of feldspars and mafic minerals.	Generally 50-75 percent.	Generally 90 percent.	Medium to high ..	Medium to high ³ .	0.3-3
Unweathered rock	No iron stains to trace along joints. No weathering of feldspars and micas. No sheared zones.	>75 percent (generally >90 percent).	Generally 100 percent.	Low to medium..	Very high ³ .	—

¹The descriptions provide the only reliable means of distinguishing the zones.

²RQD stands for Rock Quality Designation, described in Deere and others (1947). RQD in percent equals length of core pieces 4 in. (10.3 cm) and longer divided by length of run times 100. NC core diameter is 1.75 in. (4.5 cm).

³Considering only intact rock with no adversely oriented geologic structures.

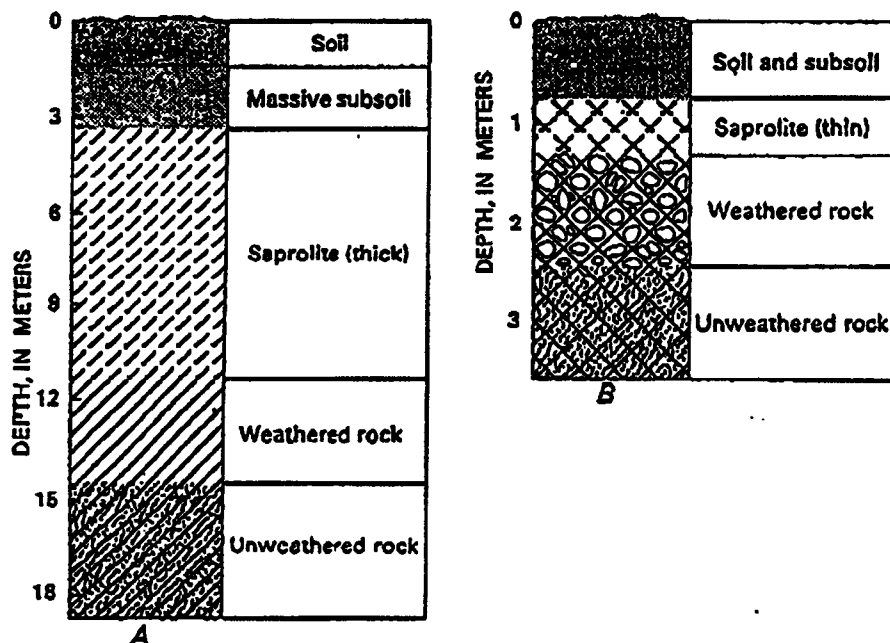


Figure 1 Generalized weathering profiles developed on crystalline rocks of the Piedmont in Fairfax County, Va. (modified from Langer, 1978). A, Foliated metasedimentary and granitic rocks. B, Massive igneous rocks (such as diabase).